15 Pulmonary Artery Analysis

The **Pulmonary Artery Analysis** (PAA) application provides semiautomatic and manual tools to help visualize and measure Pulmonary Embolism (PE) in adults.

PAA supports loading airway tree **Results** saved from the **COPD Analysis** application.

PAA consists of 2 workflow stages:

- **Find Filling Defects**. Use the semiautomatic and manual tools to visualize the lungs, review CAD results (if enabled), as well as mark and report any PE findings.

- **Cardiac Analysis**. Extract, save, and report the relevant cardiac measurements for PE identification, such as RV/LV ventricular ratio and chambers volumes, using manual and semiautomatic tools.

Supported Scan Types

The application supports chest volumetric CT data, including axial, contrast-enhanced, ECG-gated or non-gated chest scans.

WARNING

When loading images into the application, all images which contain 16 bit data are converted into 12 bit images. (Therefore, when the rescale intercept equals -1000, Hounsfield Unit values above 3095 are displayed as 3095, and when the rescale intercept equals -1024, Hounsfield Unit values above 3071 are displayed as 3071.)

Indications for Use

The CT Pulmonary Artery Analysis application (PAA) is designed to assist during the assessment of suspected findings of Pulmonary Embolism (PE) in adults.

Launch Pulmonary Artery Analysis

Select the desired **Study** in the **Directory** and select **Pulmonary Artery Analysis** from **Analysis** applications menu.

1. From the **Patient Directory** find and select the desired **Study** and **Series.**

2. Select the **PAA** icon   from the application icon chart.

3. The application opens in the **Find Filling Defects** stage.

Loading Multiple Series

When more than one **Series** is loaded to the application, **PAA** runs the CAD (if enabled), segmentation, and extraction algorithms based on the order of **Series** being loaded. During processing, the common visualization and editing tools are available.

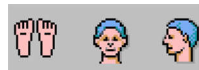You can switch between **Series** by clicking on the **Series** tabs across the top of the display.
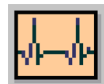
Loading a Series with Previously Saved Results

Saved airway tree **Results** from the **COPD Analysis** application may be loaded to the application, as well as any previously saved **PAA** results.

Pulmonary Artery Analysis Options, Tools and Functions

Use the common tools and processes to perform many basic tasks, including: saving, filming, reporting, scrolling, measurements/annotations, panning, zooming, rotating, and windowing during all stages of **Pulmonary Artery Analysis**.
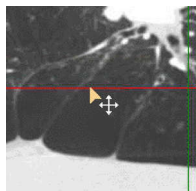
See **Report**, **Film**, **CT Common Processes** and **CT Common Tools** for information on using common options, tools, functions, and processes.

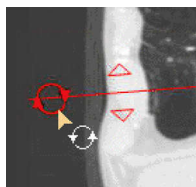| Viewing Tools and Options	
Orientation	Use these buttons to select the viewing orientation of the main viewport: axial, coronal, or sagittal.
Layouts	Click the down arrow to select an alternate layout. The currently active layout is displayed as the icon. Use the tool to launch the **Layout Manager** to create a custom layout (see the **CT Common Processes** section for more).
Relate	**Relate** is allows you to relate a location on one image of the patient to that location as viewed on other image(s) of the patient. Use the drop-down to access scene and view port options.
Show ECG Viewer	Click the **Show ECG** button to display the ECG strip (if it was loaded) along the bottom of the screen. See the **Cardiac Viewer** section in the **CT Review** section for information on using the ECG viewer.

Crosshairs

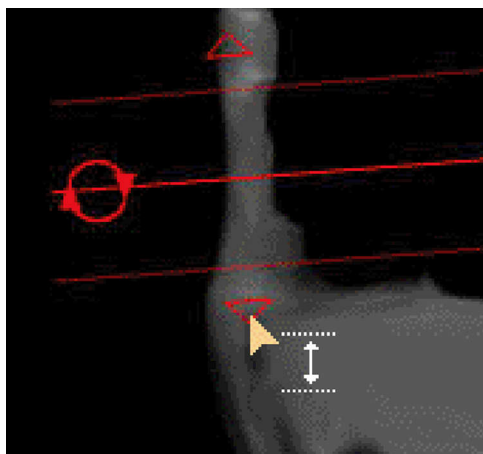For viewports with crosshairs, perform one or more of the following to adjust:

- Grab the crosshair and drag it to the correct position.

- To rotate, grab near the end of the crosshair and drag in the appropriate direction.

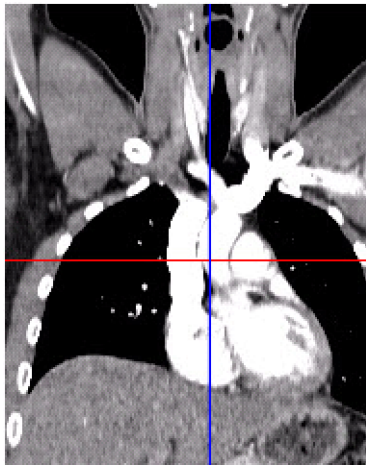- To change thickness of the images represented by the crosshair, grab the triangle and drag it.

Some applications display a hole in the center of a crosshair by default. A hole in the crosshair prevents hiding important anatomical structures.
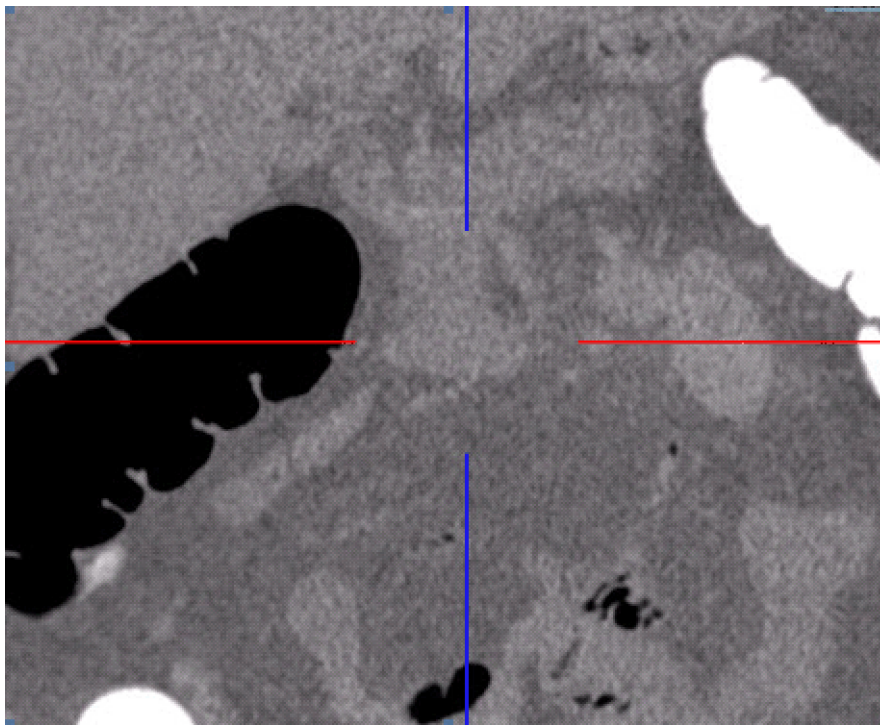
The right click menu on the crosshair allows switching between modes where the hole in the crosshair is displayed/not displayed.

Once crosshair settings are selected, (Show short crosshair, Hide crosshairs center, Show short/long crosshairs), these settings are remembered the next time the application is opened by the same user.

The **Show Crosshair Center** option shows a continuous crosshair without a hole.

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The **Hide Crosshair Center** option shows a crosshair with a hole

Shortened Crosshairs

In order to minimize the possibility of crosshairs hiding anatomical structures, it is possible to display shortened crosshairs and to only show the crosshairs where relevant.

- To switch to a shortened crosshair mode, right click on the crosshair and select **Show short crosshairs**.

- To switch to the default (long) crosshair, right click on the crosshair and select **Show long crosshairs**.
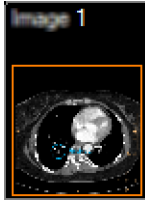
Common Functions

- **Bookmarks**. This function allows you to access **Bookmarks**, if any are saved.
- The **Create movie or series** function allows you to create a series of sequential images for viewing, saving, reporting and filming purposes.
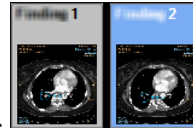
Findings Navigator

There are two types of findings that can be added to the Findings Navigator:

- **Images**. Any image from the viewport can be added as an image. These images are marked
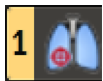

  with a black color.

- **PE findings**. These findings are specific to the PAA application and are marked with a gray

  color if not active or with a blue color if active.

All **Findings** may be saved and sent to film or report using the **Findings Navigator**. See **CT Common Tools** in the **CT Review** section for more information.
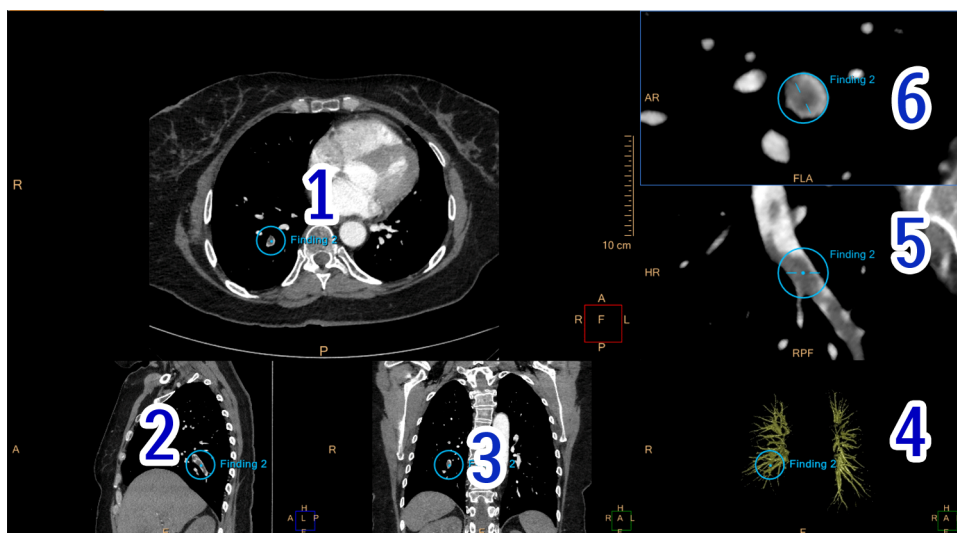
Find Filling Defects Stage

Use the semiautomatic and manual tools to visualize the lungs, review CAD results (if enabled), as well as mark and report any PE findings.

Find Filling Defects Default Layout

The viewports are linked: for example, when using **Roll/Rotate** or when scrolling through slices, linked viewports automatically update.

Upper-left viewport: main axial image (item 1).

Lower-left viewport: sagittal reference image (item 2).

Lower-middle viewport: coronal reference image (item 3).

Lower-right viewport: volume image (item 4). Use the viewport controls to change views:

- **Pulmonary Arteries (PA) tree**, default view. When segmentation is complete, CAD findings, if enabled, are displayed on this viewport.
- **All.** Displays the entire volume of the scan.
- **Bronchial Tree**. If saved in the **COPD Analysis** application, shows the bronchial-tree tissue.

Right-middle viewport: longitudinal image (item 5). Only active when a **Finding** is selected in the **Findings Navigator**, or when a CAD suggestion is selected from the CAD list.

Right-top viewport: cross-sectional image (item 6). Only active when a **Finding** is selected in the **Findings Navigator**, or when a CAD suggestion is selected from the CAD list.

Find Filling Defects Options, Tools and Functions

In addition to the basic **PAA** tasks (see section "Pulmonary Artery Analysis Options, Tools and Functions" on page 383), the **Find Filling Defects** stage has additional selections to control views and perform analysis.

See **Report**, **Film**, **CT Common Processes** and **CT Common Tools** for information on using common options, tools, functions, and processes.

| Tools and Options	
Crosshair	Click the button to display the crosshair on the reference viewports. If a **Finding** is active, it is initially placed in the center of the crosshairs on the reference viewports. To adjust crosshairs, see section "Pulmonary Artery Analysis Options, Tools and Functions" on page 383.
Rotation Center	Click to show the center point around which the volume can be rotated.
Center Cursor	This function centers the image around the rotation center. Change the rotation center as follows: 1. Click on the **Rotation Center** button and move the mouse over the current rotation center (the green X) in the slab view. The mouse pointer turns into an arrow cross symbol. 2. Drag the rotation center to the desired region of interest. 3. Click **Center Cursor** and the slab view centers around the new rotation center location. Swiveling and rotating of the image will be performed around this new rotation center.
Quick Windowing	Use the button to switch between the default (vessels) view and the lungs view, which may provide an optimized view for reviewing images of the lung. You can also use the keyboard shortcut **Q** to switch between views.
Show Non-active Findings	Place a check mark in the checkbox. For example, If multiple findings have been marked on a single slice, only the active finding in the **Findings Navigator** is shown by default. To show all findings for the slice, place a check mark in the **Show non-active findings** check box to show all findings on the axial, coronal and sagittal viewports. When the option is checked, all findings are shown in the volume (PA Tree) viewport in the bottom right. Remove the check mark from the check box to only show the active finding.
Show Colormap	Select the button to display a HU-based colormap on the main and reference images.

WARNING

The colormap should not be used as a SOLE basis for diagnosis. Use the middle mouse to adjust the colormap to the loaded data."

Review Lung Images and Mark Findings

Focus on the lungs, mark **Findings** using the **PE Detection** tools, and verify **Peripheral CAD Suggestions** (if available).

1. Select either the **Focus on Left Lung**   or **Focus on Right Lung**   button.

2. Scroll through the images and review the lung.

3. Activate the **Mark New Finding** button   and click on the either the main or a reference viewport to add a new **Finding**. Use the **Findings Navigator** tools to rename, classify, annotate, film, report, and save the **Finding** (see **CT Review > CT Common Tools** for more information).

4. When done, focus on the other lung and repeat the review and mark-findings process.

5. Select the **Focus on Both Lungs** button   and repeat the review and mark-findings process.

6. To delete a **Finding**, right-click on it in the **Findings Navigator** or right-click the **Finding** on the image.

Review and Mark Findings in Paddle Wheel Mode

The **Paddle Wheel** mode allows you to scroll and view images radially around the X-Axis or Y-Axis. The location of the line in the volume is determined by the crosshair on the reference images.

1. Click the **Paddle Wheel** button   .

2. Select X-Axis or Y-Axis from the viewport controls (the horizontal axis is active by default).

3. Use the left mouse button on the main viewport to navigate through the generated paddle wheel MPRs. The image rotates around the axis that is set by the crosshair in the reference images. The reference images remain constant.

4. Activate the **Mark New Finding** button   and click on the either the main or a reference viewport to add a new **Finding**. Use the **Findings Navigator** tools to rename, classify, annotate, film, report, and save the **Finding** (see **CT Review > CT Common Tools** for more information).

5. To delete a **Finding**, right-click on it in the **Findings Navigator** or right-click the **Finding** on the image.

Accepting and Rejecting Peripheral CAD Suggestions

The Computer Assisted Detection (CAD) option detects only peripheral filling defects after automatic segmentation of the lungs and PA tree were performed. When complete, the **Peripheral CAD Suggestions** are displayed as **CAD Findings** on the relevant slice(s) and in the **PA Tree** viewport.

NOTICE

The CAD suggestions are displayed as annotations on single slices (not necessarily in the middle of the finding nor in the most blocked region of the vessel). Scroll to the neighboring slices to review the entire CAD finding.

NOTICE

Depending on your system, the CAD option may not be available.

Peripheral CAD Suggestions must be reviewed before they are added as findings to the Findings Navigator.

⚠ **WARNING**

The Pulmonary Artery Analysis CAD option should not be used as the SOLE basis for clinical diagnosis.

1. If the CAD option is available, click on the **Show Peripheral CADs** button ⊕ to display them in the **Pulmonary Arteries (PA) tree** viewport (bottom right).

2. Select a **Peripheral CAD Suggestion** from the table or click on it in the viewport.

3. When the Peripheral CAD Suggestion is displayed in all viewports, accept or reject the suggestion by right-clicking on it on one of the viewports.

4. Accepted **Peripheral CAD Suggestions** are added as Findings to the **Findings Navigator** where they can be reviewed and modified similarly to any manual **Findings** you have added.

5. Rejected Peripheral CAD Suggestions are removed from all viewports and from the **Peripheral CAD Suggestions** list. Once a Peripheral CAD Suggestion is rejected, the next Peripheral CAD Suggestion on the list is displayed.

6. You can use the keyboard shortcut **>** to move to the next Peripheral CAD Suggestion on the list.

NOTICE

Automatic segmentation of the lungs may fail in cases where the scan FOV does not include the entire lung volume. In such cases, the **Focus** and **Show Peripheral CADs** buttons are not enabled. In this case, use manual tools such as Pan, Zoom and Mark New Finding.

Annotate PE Findings

To annotate a **PE Finding**, activate it in the findings tray, and then hover or click on it again. You

can also use the **Preview** button on the findings tray.

Use the drop-down menu to select from the pre-populated drop-down menu for name, lung, lobe, segment, and other properties.

To manually enter properties or comments, type in the appropriate box.

NOTICE

The application supports both **PE Findings** (marked as **Findings**) and standard **Findings** (marked as **Images** by default).

Although both types of findings are added to the findings navigator, the functionality is slightly different. **PE Findings** include application-specific options and functionality that the standard **Findings** do not. For example, clicking on a PE finding on the tray (marked as **Findings**), will activate the finding and display it in all of the viewports, unlike standard findings (marked as **Images**).

All **Findings** may be saved and sent to film or report using the **Findings Navigator**. See **CT Common Tools** in the **CT Review** section for more information.

Verify and Edit PE Finding

Once a **Finding** has been marked (see section "Review Lung Images and Mark Findings" on page 389), verify the cross-section and longitudinal images. When done save selected images to the active **Finding**.

NOTICE

Double click on an image to open it in full screen mode.

Verify and Edit Findings

To reposition the finding annotation on the axial/coronal/sagittal images, hover over the finding annotation and drag it to the desired position. All images and the finding thumbnail on the tray will be updated to the new finding location.

Examine Additional Locations on the Longitudinal Image

Grab the center point on the longitudinal image to drag it to a new position (upper image). The annotations on the longitudinal and cross-sectional images change their display to a green **x** and will be correlated to the rotation center position (middle and bottom images).

Adding Additional Images to a Finding

1. Click on a finding in the findings tray to activate it.

2. Right-click on the image to be added and select **Findings.**

3. Add the active image to this finding from the menu.

Alternatively, drag the image to the relevant finding using the right mouse button.

Adding Images of Interest to the Findings Navigator

1. Right-click on the image to be added and select **Findings.**

2. Add the selected image to Findings Navigator using the menu. Alternatively click on the

   Add selected image to findings navigator button on the tray or press the space button.

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Adding the Display to the Findings Navigator

Click on the **Add display to findings navigator** button on the tray or press the **<Shift>** +**<space bar>** keys.

Cardiac Analysis Stage

Extract, save, and report the relevant cardiac measurements associated with PE severity, such as RV/LV ventricular ratio and chambers volume, using manual and semiautomatic tools.

There are two methods for calculating the RV/LV ratio:

- **2D RV - LV Ratio Method** - Manually set the RV and LV planes starting from axial view, and draw the maximal diameters. Manually set the RV and LV planes starting from 4-Chambers view, and draw the maximal diameters.

- **3D Ratio Method** - Extract the RV/LV volumetric ratio based on volumetric segmentation, edited, and accepted.

2D RV - LV Ratio Method

Manually set the RV and LV planes and draw the maximal diameters.

By default, the **PAA Cardiac Analysis** stage opens to the **2D RV - LV Ratio method** tab.

2D RV - LV Ratio Method Default Layout (Planar Mode)

The RV viewports (items 1, 2, and 3) and LV viewports (items 4, 5, and 6) are not linked by default: you can scroll or swivel through them independently (use **Align and Link RV&LV Planes** to connect all viewports).

NOTICE

If the **Align and Link RV&LV Planes** feature is used after one diameter is marked, both axial images will align to the image that is marked (not necessarily the active image).

If the **Align and Link RV&LV Planes** feature is used after both diameters are marked, you will need to delete one of the diameters and then redraw it.

NOTICE

To adjust the crosshairs, see section "Pulmonary Artery Analysis Options, Tools and Functions" on page 383.

Upper-left viewport (item 1): RV plane used to draw the maximal RV diameter.

Lower-left viewport (item 2): RV plane coronal reference image.

Lower-left-center viewport (item 3): RV plane sagittal reference image.

Upper-right viewport (item 4): LV plane used to draw the maximal LV diameter.

Lower-right-center viewport (item 5): LV plane coronal reference image.

Lower-right viewport (item 6): LV plane sagittal reference image.

Set Planes and Draw Diameters

1. Choose either the **Axial** or **4-Chambers** view to be used for setting the desired plane.

2. Click on either the RV or LV viewport. Scroll through the images to find the appropriate image on which to draw the diameter.

3. If necessary, select **Align and Link RV&LV Plane** to align the non-active plane by orientation, zoom and pan to that of the active plane.

4. Select either the **Draw RV Diameter** or **Draw LV Diameter** button on the top of the viewport. Click where the diameter should begin. Locate the ending of the diameter and click to add the diameter.

    – To move the diameter line, grab it and drag to a new position.

    – To adjust the diameter length, grab a control point and drag in any direction.

⚠ **WARNING**

When trying to draw the LV maximal diameter on the RV plane, a message is shown: You cannot draw the LV Max diameter on the RV plane. Please use the image on the upper right to draw the LV Max diameter.

When trying to draw the RV maximal diameter on the LV plane, a message is shown: You cannot draw the RV Max diameter on the LV plane. Please use the image on the upper left to draw the RV Max diameter.

When trying to draw the RV diameter on the wrong tissue, a message is shown: Note, The RV max diameter seems not to be drawn on the right ventricle. Please re-draw the diameter on the correct ventricle.

When trying to draw the LV diameter on the wrong tissue, a message is shown: Note, The LV max diameter seems not to be drawn on the left ventricle. Please re-draw the diameter on the correct ventricle.

5. Select the other image and repeat the previous step.
6. Add your findings to the **Findings Repository** to save or send them to **Report** and **Film** applications. See **CT Common Tools** in the **CT Review** section for more information.

Review Results

The diameters values and ratio appear on the 2D Ratio calculation measurements table. Click on the table to display the images with the drawn diameters.

NOTICE

The active table may be added to the clipboard using **Ctrl + C** or by right-clicking on the table and selecting copy. The measurements may then be pasted into common document types, including plain text, Microsoft Word, and Microsoft Excel documents.

3D Ratio Method

Extract the RV/LV volumetric ratio based on volumetric segmentation.

⚠ **WARNING**

Verify the accuracy of the automatic segmentation. If necessary, manually correct the segmentation using the segmentation-correction tools provided in this stage.

Verify and Edit RV/LV Volumetric Segmentation

Verify and, if necessary, edit the extracted cardiac tissues: left ventricle; right ventricle; left atrium; right atrium; LV myocardium; and aorta.
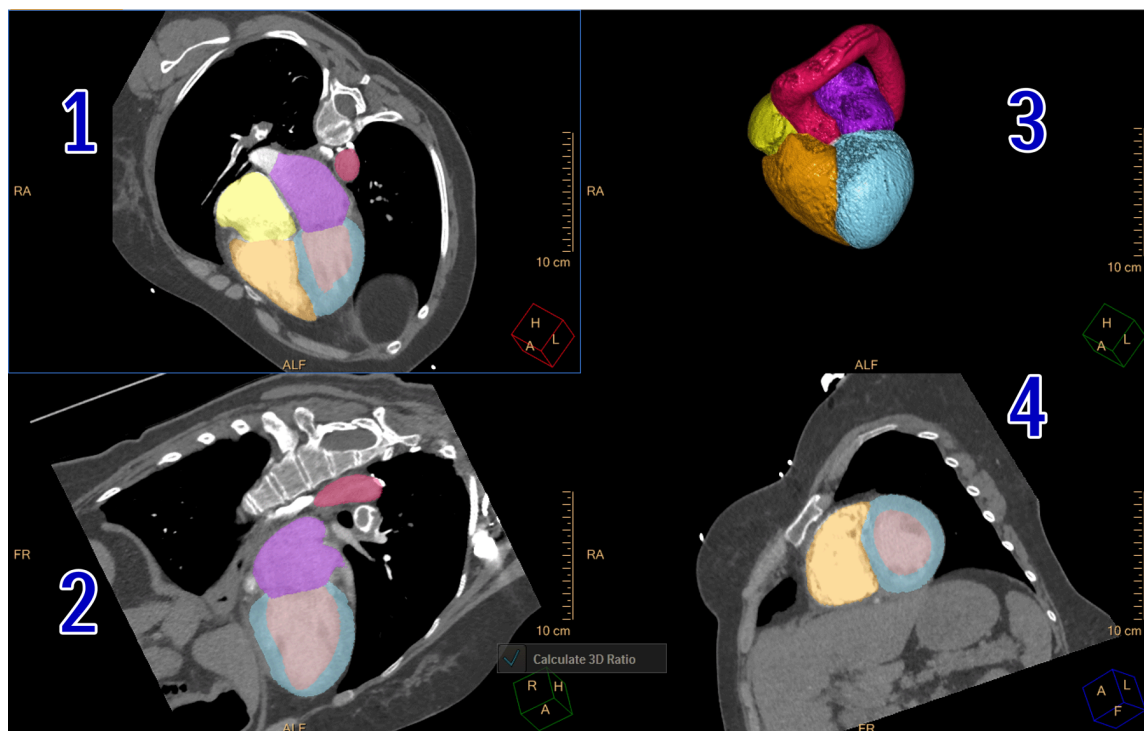
Upper-left viewport: 4-chambers cardiac orientation image (item 1).

Lower-left viewport: 2-chambers cardiac orientation image (item 2).

Upper-right viewport: volume image (item 3).

Lower-right viewport: short axis cardiac orientation image (item 4).

NOTICE

See **CT Common Tools** in the **CT Review** section for information on using the **Edit Tissues Tools**.

1. Select a tissue from the tissue list and review the segmentation.
2. Use the **Edit Tissues Tools** to edit the segmentation as needed.
3. Select, review, and edit the remainder of the tissues in the tissue list.
4. When done, click the **Calculate 3D Ratio** button.

Review Results

The RV&LV, RA&LA volume measurements and ratio are displayed on the 3D Ratio Calculation (Volume) table.

NOTICE

After clicking the **Calculate 3D Ratio** button for the first time and then editing segmented tissues, the table measurements are updated accordingly.

NOTICE

The active table may be added to the clipboard using **Ctrl + C** or by right-clicking on the table and selecting copy. The measurements may then be pasted into common document types, including plain text, Microsoft Word, and Microsoft Excel documents.